

MEASURES OF SUSCEPTIBILITY TO NERVOUS BREAKDOWN¹

W. HORSLEY GANTT, M.D., BALTIMORE, MD.

I

An urgent problem in modern psychiatry is the prevention as well as the cure of nervous diseases. For this purpose it is necessary first to assay the vulnerability of the individual, by placing him in a test environment which will not impose too great a burden upon his nervous system.

Our present methods have been inadequate for this detection; treatment has proceeded much further than prevention. It is true that we obtain important information from the biographical (both family and individual) data, but this is difficult to get and often more difficult to evaluate; no careful records are available concerning the majority of individuals outside of a hospital. Furthermore this type of information does not come from controlled situations. The methods of psychiatric examination, in contrast to those of physical examination, have been based mainly upon verbal reactions. The I. Q. and mental status often bear little or no relation to what interests us chiefly about the patient. The E. E. G., thought objective, is poorly understood at present and probably measures metabolic factors which may or may not be related to the elements of vulnerability to nervous breakdown.

A method is required which is (1) *objective* (therefore varying minimally with the examiner); (2) capable of being *recorded* (and thus available for comparison by day to day and from one individual to another); (3) *quantitative* to a certain degree; (4) concerned with *significant* items, having a high correlation with the characteristics of the patient that are essential, viz., those that determine his susceptibility to break under stress.

The method proposed here for detecting vulnerability actively imposes a certain task upon the nervous system comparable to the various functional tests used in medicine for

the heart, kidneys, liver, etc. In this new method it is necessary first to establish the normal record for the given individual, *i. e.*, his simple performance in an ordinary situation not too difficult; second, to place the individual under a graduated stress; and third, to detect the point at which the subject begins to deviate from the normal. It is important to note that the normal must be determined for that particular individual because what is normal for one is not normal for another; "one man's meat is another man's poison."

I. *The Establishment of the Norm.*—In spite of the general recognition now among psychiatrists of psychosomatic relations, I

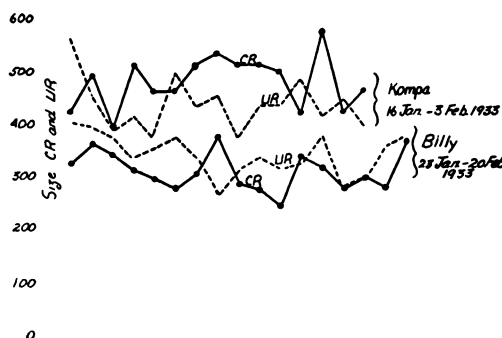


FIG. 1.—Comparison of daily variations of CR and UR in two dogs.

wish to ascribe proper credit to Pavlov for having first irrefutably demonstrated experimentally the truth of "no psychosis without neurosis," viz., that the psychical can be objectively recorded in a somatic reaction. For this he used the salivary secretion as a measure of psychic excitation or inhibition. The conditional reflex is the measure of this somatic reaction.

That psychic phenomena are as subject to laws as the so-called physiological has been clearly demonstrated. In this laboratory it has not only been shown that there is as little daily variation (in a rigidly controlled situation) of the conditional reflex (cr) as of the unconditional (UR) (Fig. 1), but the cr can be expressed in an equation as readily as can the UR. Thus for the salivary

¹ Read at the ninety-eighth annual meeting of The American Psychiatric Association, Boston, Massachusetts, May 18-21, 1942.

From the Phipps Psychiatric Clinic, Johns Hopkins University, Baltimore, Md.

cr the formula is $cr = a + b(1 - e^{-cQ})$,² an exponential relationship, while for the UR secretion of salivation the formula, $UR = a + bQ$, shows a linear relationship.

These formulæ simply mean that as the intensity of the stimulus is increased the cr at first increases but soon stops increasing or increases very slowly with added stimulation; while within the same limits the UR increases equally with each unit of added stimulus whether the unit is added to the basic large or small stimulus. Individual variations are accounted for by the constants (for a given individual) a , b , c .

We have extended the work of Pavlov to other autonomic functions. The sensitiveness of the heart rate in human subjects has been demonstrated by Whitehorn, and the cardiac conditioned reflex in dogs is one of the most interesting to show a quantitative relationship to the stimulus. For each individual there is a certain change in the heart rate accompanying each type and intensity of excitatory cr, and another change in the heart rate accompanying inhibition. That the cardiac cr is a more delicate measure of activity is convincingly shown by its persistence in dogs after a long period of rest when the other components (motor and secretory) have disappeared (experiments of Tunick in this laboratory). Thus the heart rate is a reliable quantitative measure of the intensity of conditioned excitation and inhibition. This seems the more remarkable when we consider that these measures of heart rate are made for very short periods, viz., 3 to 10 seconds, while the conditioned stimulus is acting.

The following chart (Fig. 2) shows that there is a change in heart rate during the cr which is practically equal to the change in heart rate during the UR and that there is a smaller change in heart rate during inhibition. That the increase in heart rate accompanying the cr represents a measure of the conditional reflex or emotional tension, or in other words the conditional excitation is

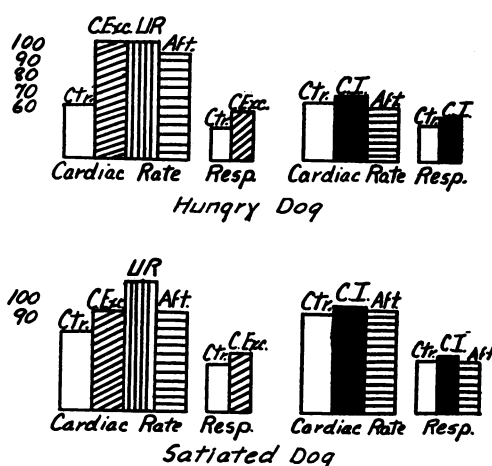
² Gantt, W. Horsley. The nervous secretion of saliva: the relation of the conditioned reflex to the intensity of the unconditioned stimulus. *Am. J. Physiol.*, 123: 1, 74, July 1938.

Gantt, W. Horsley. The origin and development of nervous disturbances experimentally produced. *Am. J. Psychiat.*, 98: 4, Jan. 1942.

shown by the fact that in a satiated dog there is no conditional secretion nor a cardiac cr during the signal for food, and the animal also refuses to take the food.

Changes in respiration accompanying the crs have been frequently noted (Bechterev, Watson, Kellogg, Gantt, Liddell).

II. *The Production of Strain.*—Some physiological conditions, as well as pathological, produce internal states which lower the threshold at which the breakdown occurs, make the animal highly susceptible. Thus during the postpartum period in the dog,



Ctr. = Control.
C. Exc. = Excitatory conditioned reflex.
UR = unconditioned reflex.
Aft. = heart rate immediately following UR.
C. I. = inhibitory conditioned reflex.
Resp. = respiratory rate.

FIG. 2.—Excitatory and inhibitory crs before and after satiation.

simply subjecting the animal to the routine conditional stimuli results in an imbalance. This was first noted in a dog (Kompa) in 1930 and it has been seen subsequently in others. The following chart (Fig. 3) shows the drop in the salivary cr in Kompa on the first few days postpartum. In another dog (Zee) no change was observable in the motor crs, but by taking a more delicate measure, viz., the cardiac cr, it is evident soon after the birth of the puppies that there is a deviation of activity recorded in the cardiac crs (Fig. 3). A similar disturbance occurs in male dogs confined near a dog in estrus.

Natural emotional shocks also produce marked disturbances in the cr activity, al-

though these cannot always be observed by the usual means of examination. Two examples follow. In April 1931 the dogs in the laboratory escaped from the paddocks, got into strange surroundings, and had to be forcibly returned; they fought among themselves and were whipped by the night watchman. Fig. 4 shows the change produced in the cr activity in various individuals; the stable animal (Billy) was only slightly affected while an excitatory one (Kompa) was severely disturbed as was the inhibitory animal (Blue). After this event there were parallel changes in the ordinary observable behavior, Billy being affected very little and only for one day, while Kompa

revealed the much greater deviation in the labile Kompa than in the stable Billy; similar to the change seen in Fig. 4.

In the above instances it was only by establishing previously a normal base line that we were able to see the pathological state reflected in the cr; for the criterion is *a change from the normal for that particular individual*.

Let us next consider artificial strain—produced deliberately and under controlled conditions in the laboratory, and the way in which dogs of different temperament behave under this imposed stress.

It is necessary to emphasize that by no ordinary method of observation was it pos-

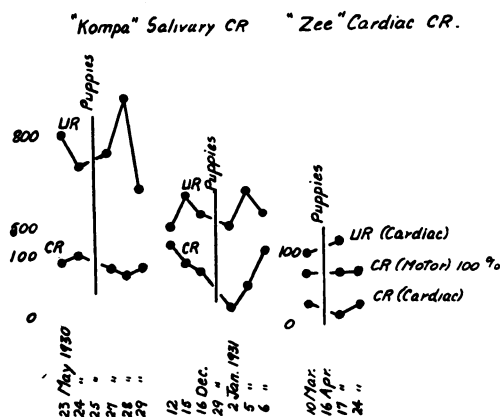


FIG. 3.—Effect of parturition on CR.

was much subdued for three days; and Blue slunk into the corner and kept his tail tucked though he was usually friendly and playful, and was inactive for a week. However the change in the crs outlasted any disturbance of behavior that could be detected by ordinary observation.³

Another instance occurred in 1932, involving the labile dog Kompa and the stable Billy—showing that the stable one was again stable and the labile one (Kompa) disturbed for a long time. These animals were seen fighting on March 18, 1942. They had been fighting for about 24 hours, and appeared equally exhausted and wounded; they could barely walk and had to be carried to the experimental camera. The salivary cr record

³ For a detailed account of this condition see Gantt, W. Horsley. *The Experimental Basis of Neurotic Behavior*. Harper Bros., N. Y. 1943.

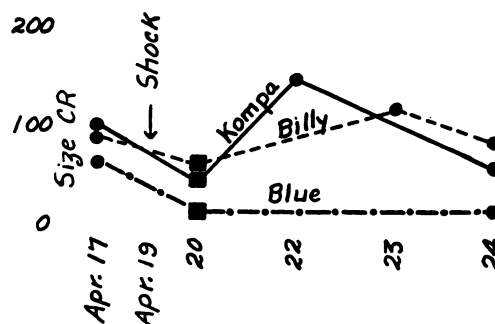


FIG. 4.—Effect of natural emotional shock (escape from paddock) on CR in 3 types dogs—excitatory labile (Kompa), stable (Billy) and inhibitory labile (Blue).

sible in these dogs to distinguish the susceptible and labile from the stable. I have asked many psychiatrists and physicians and I have tried myself to predict from ordinary contacts with the dogs or from knowledge of their breed, etc., which ones will break down first. Even after long periods of ordinary observation gained by playing with and feeding the animal, accurate prediction is not possible. The individual must be placed under a definite stress and deviation from his normal measured. Photographs of these dogs did not reveal which are susceptible, although the following test situations do.

In dogs C and D the establishment of crs was started at the same time. From the next chart you will see that C quickly made a differentiation between the inhibitory and excitatory metronoms, giving the proper response to each, while D is hyper-reactive, con-

tinually reacting to the inhibitory as well as to the excitatory stimuli. D also showed more disturbance of the overt behavior in the test situation—*e. g.*, whining, restlessness and barking. The first chart (Fig. 5) is a record of the crs measured by the muscular movements—the withdrawal of the foot to the signal for a faradic shock.

The next charts (Figs. 6 and 7) show the parallel change in the respiration: even at

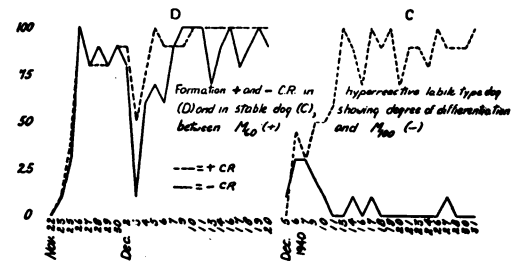
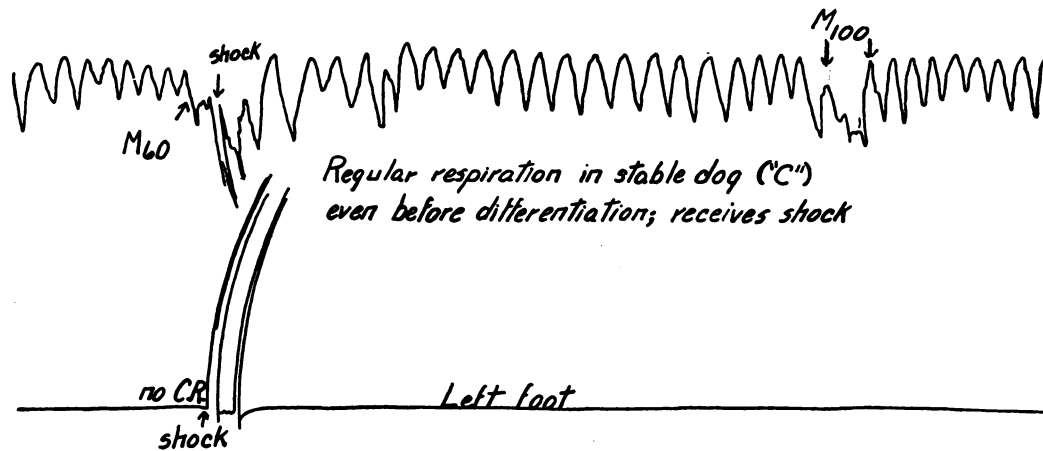


FIG. 5.—Differentiation in labile and stable dogs.



Dec. 6, 1940.

FIG. 6.

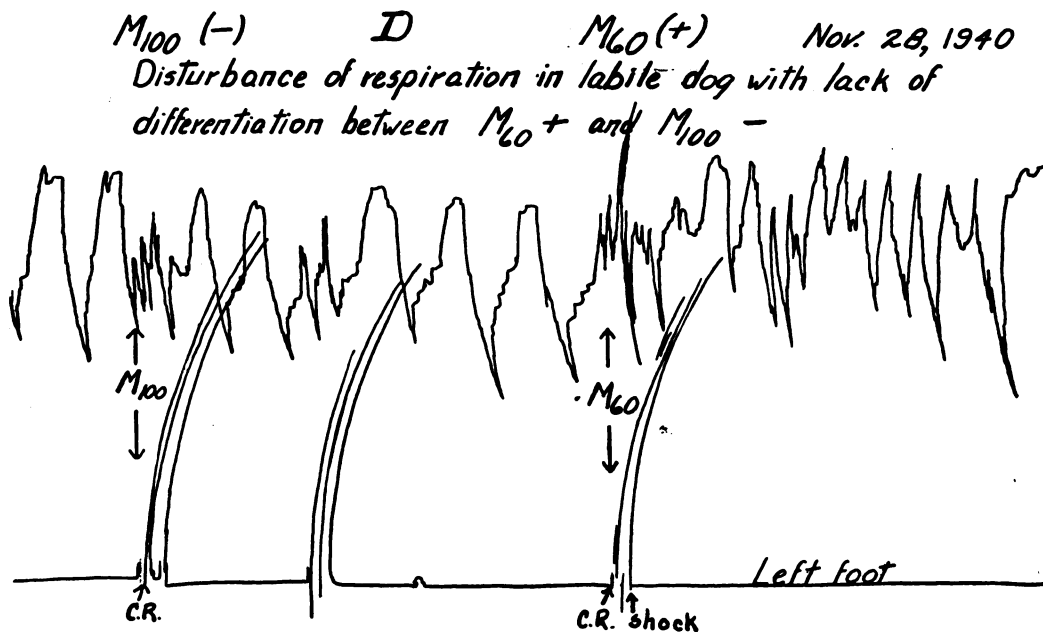


FIG. 7.

the time that C could not make the differentiation there was little disturbance in the respiration, but in D there were marked changes evident though only when the differentiation became difficult.

The cardiac crs showed a parallel disturbance. Normally both dogs give changes in the heart rate during the action of the conditioned reflex; but in C the changes were not so marked as in D. The difference in the two dogs is brought out much more clearly in the cardiac crs where the situation is made more difficult, thus on Novem-

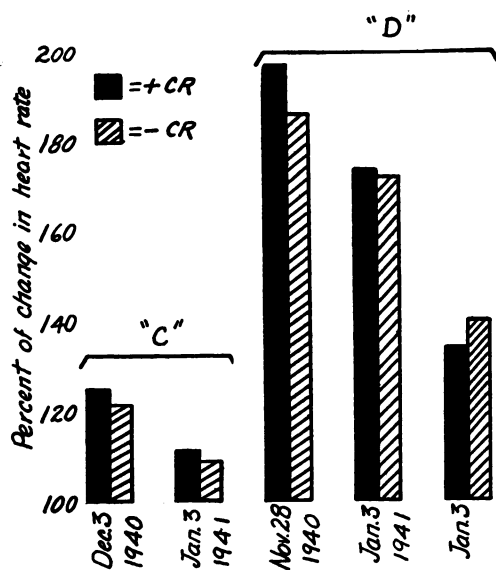


FIG. 8.—Conditioned cardiac rates in stable dog (C) and labile dog (D) during strain (Nov. 28–Dec. 3) and during good differentiation (Jan. 3). Control represented as base line, 100%.

ber 28, 1940, in D the cardiac rates increased from 100/min. with the normal cr to about 200 with the cr when the differentiation was difficult (Fig. 8). Actually C showed a decrease in heart rate to the normal cr but a greater decrease to the difficult differentiation, while D had an accelerated heart rate to the normal cr but a more marked acceleration with the difficult differentiation. Whether the heart rate is decreased or increased depends upon the individual.

The salivary secretion is an autonomic function that has been made the conventional measure of the Pavlovian cr. Fluctuation from the normal behavior may begin

with a disturbance too slight to be detected by present methods in any other way than by the measure of the autonomic cr, and if the conflict is prolonged the deviation may continue until not only all the artificial laboratory crs are abolished in the situation of conflict but also even all crs to the old strong stimuli (sight and smell of food). An example of the acute disturbance is seen in the chart of Kompa; the introduction of an inhibitory metronom depressed the old well-established crs but for a period of only five to ten minutes after the disturbing metronom. Each time the inhibitory metronom was given (for 30 seconds) the effect of subsequent positive conditional stimuli was diminished or reduced to zero. Recovery occurred within a few minutes. However in another dog, Nick, all the positive food crs (motor and secretory, natural and artificial) were abolished when the animal was simply brought into the old environment—even as long as 9 years after the original conflict—but the unconditional reflex secretion was unchanged. Thus on March 2, 1932, before the conflict the cr salivary secretion was 0.4 cc. in 10 seconds but on June 27, 1932, after the conflict and even to 1942 the cr secretion remained zero. In contrast to the labile dog, Nick, in the stable dog, Fritz, subjected to the same environment of conflict there was only a slight disturbance in ordinary behavior and in the salivary crs which lasted for a few days instead of years.

The external behavior of the two dogs under strain—in the laboratory situation of conflict—is often significant, but seeing the two animals under ordinary circumstances would not give a clue as to which one would break down. To the same tone that was used several years previously in a difficult differentiation connected with food Nick tugs to get away from the source of the tone, panting, tense, with a marked sexual erection, while Fritz pays no attention to the tone but calmly looks toward the experimenter.

Although we are not concerned here with chronic changes except as evidence of the lability, Nick had a pronounced gastric hyperacidity (experiments in collaboration with Arnold Rich) in the environment of conflict.

The sexual reflexes are a delicate barometer of the strain to which the animal is subjected. There may be with a slight conflict only a temporary change in sexual reflexes; there are in the environment of conflict on the one hand, abnormal sexual erections, and, on the other hand, a decrease in sexual activity resembling impotence.⁴

Besides the actual drop in the conditioned reflexes, the *degree of fluctuation* of both conditioned reflexes and other functions is an important evidence of pathology. This is reflected in chemical metabolic changes, *e. g.*, in the blood sugar tolerance after a glucose test meal. Diethelm,⁵ Bridge and others have shown that the curve of blood sugar bears a relation to the acute emotional state of the organism. In 3 dogs of varying susceptibility who had repeated glucose test meals it was found that the most labile (Nick) had the greatest fluctuations from day to day, that the most stable (Fritz) had the least fluctuation and that Peter whose disturbance of behavior was intermediate between Nick and Fritz, had fluctuations of blood sugar intermediate between Nick and Fritz. After standard deviations are made between all the zero hours on successive tests, all the $\frac{1}{2}$ hour readings on successive test-days, etc., again Nick shows the widest range of fluctuations; *e. g.*, that (σ) for Fritz=8.6, for Peter=10.3, for Nick=18.0.

In another function, the day's 24-hour running activity, it also appears that not the absolute activity but the *change in* this activity⁶ is the important factor of susceptibility. For example, Nick and Brenda were the two dogs with the most pronounced neurotic disturbances, but Nick was the most active and Brenda the most inactive of all in the laboratory. Nick's activity fluctuated

widely after he became neurotic; Brenda, who was formerly a pet in my home, had a remarkable drop to almost complete inactivity for several weeks, every time she was brought into the laboratory. This was parallel to her pathological behavior; she gave the signs of a marked depression, standing motionless with tail tucked, head hung for long periods, hardly moving from one spot during the 24 hours. The inactivity recurred every time she was brought into the laboratory. She finally died in the laboratory ap-

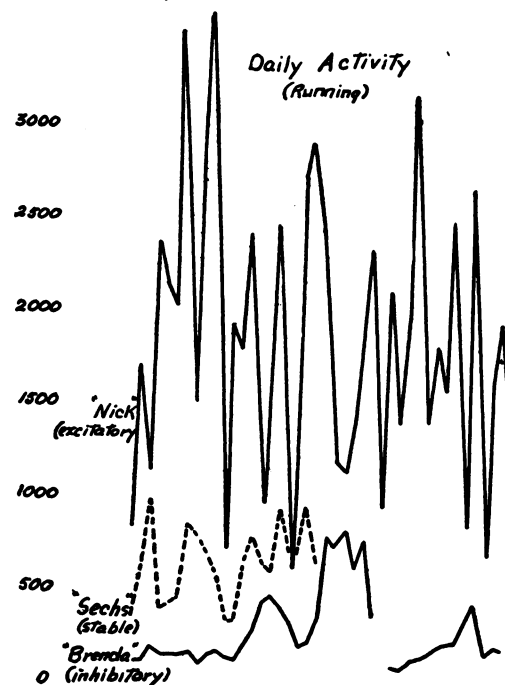


FIG. 9.

parently in a depressed condition. See Fig. 9 of the two labile dogs and the stable animal Sechs.

II

The above records on dogs convince one that susceptibility to breakdown can be detected in a variety of objective measures when the animal is placed under a definite stress. Though the method has not been so thoroughly worked out for the human subject, I have considerable data in both the normal and psychotic indicating that a similar procedure may be used. A slight artificial

⁴ This question is too complicated to discuss here; a fuller account is given in my monograph, "Origin and development of nervous disturbances in behavior of dogs experimentally produced." *Psychosomatic Medicine* (in press).

⁵ Diethelm, Oskar. Influence of emotions on dextrose tolerance. *Arch. Neur. and Psychiat.*, 36: 342-361, Aug. 1936.

⁶ Gantt, W. Horsley, and Muncie, Wendell. Analysis of the mental defect in chronic Korsakov's psychosis by means of the conditioned reflex method. *Bull. Johns Hopkins Hosp.*, LXX: 6, 467-487, June 1942.

conflict is produced by the conditioned response technic⁷; the problem is made gradually more difficult, at the same time carefully recording the reactions. In a normal subject the response is seen to be regular and undisturbed by the test situation and the differentiation, and the movements (posi-

Contrast this record with two abnormal ones. The first is an hyperactive schizophrenic with anxiety (Fig. 11). Here it is seen that the respiration is markedly disturbed, revealing the anxiety; subsequently as the patient developed the ability to differentiate there was less disturbance.

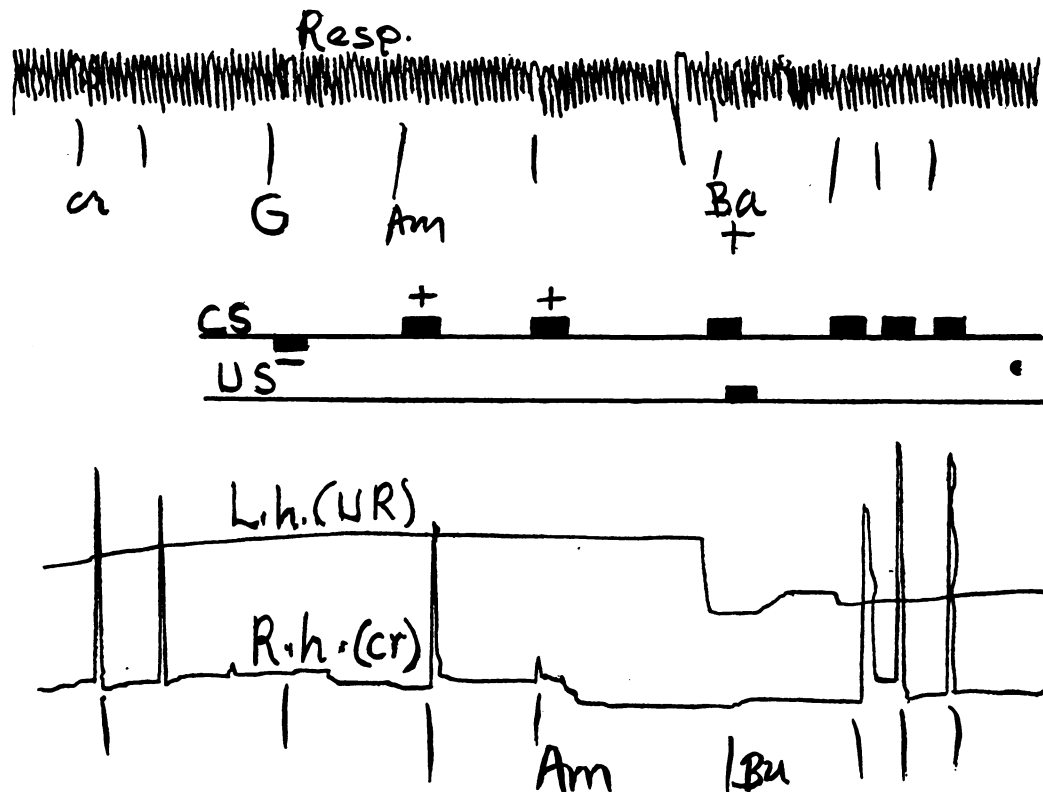


FIG. 10.—Pt. O, 11 January 1939. Normal cr formation without marked disturbance in respiration. Upper line = respiration, middle two lines mark cs and US, next to bottom line is L.h. showing chiefly URs, and bottom line is R.h. showing integrated crs.

tive conditioned reflexes) are regular and accurately related to the stimuli.⁸

⁷ A method of testing cortical function and sensitivity of the skin. W. Horsley Gantt. Arch. Neurol. Psychia., 40: 79-85, July 1938.

Impairment of the function of adaptability as measured by a simple conditioned reflex test in certain psychogenic contrasted with organic diseases. W. Horsley Gantt. South. Med. J., 31: 12, 1219-1225, Dec. 1938.

⁸ The following abbreviations are used: cr(s) = conditioned reflex(es); cs = conditioned stimulus; US = unconditioned stimulus; UR(s) = unconditioned reflex(es); l.h. = left hand, i. e., the hand receiving the US and whose recorded movements are chiefly URs, though sometimes also primary (spontaneous) crs; r.h. = right hand, i. e., the

second patient (S. R.) is a catatonic whose conditioned reflexes and unconditioned reflexes were followed during various degrees of catalepsy. On October 24, 1938, the patient was able to converse but showed some rigidity; there is conditioned reflex in the hand making the purposeful movements (lower line Fig. 12) which spreads to involve the other hand (upper line Fig. 12). On October 31, 1938, there

hand making the purposeful movements to avoid shock, whose record shows chiefly the secondary (integrated) crs; positive (excitatory) csi marked above the line; negative (inhibitory) below the line.

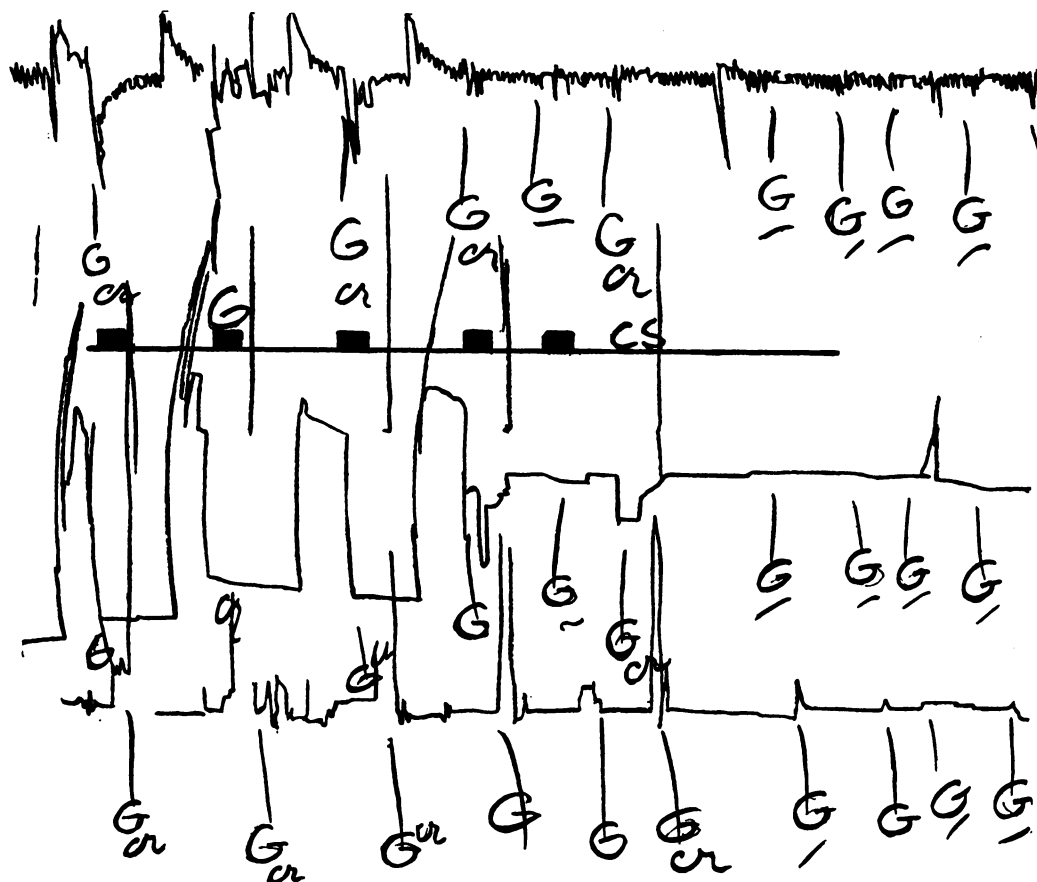


FIG. 11.—Pt. Eg., 14 January 1939. Hyperactive schizophrenic with anxiety. Note disturbance in respiration and constant irregular movements in both hands connected with inability to differentiate positive from negative signals. Upper line = respiration, middle line = cs, next to bottom line = L.h. showing cr and UR activity, and lower line is R.h. with integrated crs.

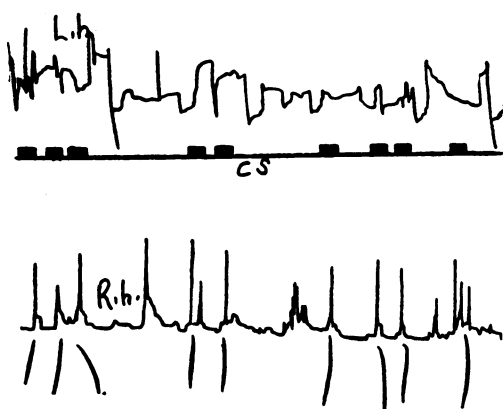


FIG. 12.—Pt. S.R., 24 October 1938. Precataleptic stage. There is successful elaboration of crs but not differentiation (bottom line), tremors indicating tension in the hand receiving the unconditioned stimulus (top line).

was increased tension with ineffective conditioned reflexes—present in both hands—and mutism; the patient had to be brought in a wheel chair (Fig. 13). On January 30, 1939, the patient was able to converse rationally; he formed adequate conditioned reflexes (lower line Fig. 14), there was little spread to the other hand (middle line), and the respiration was only moderately disturbed (upper line). However there was no differentiation between the positive amber light and the negative white light. On March 6 the patient was again cataleptic, very rigid, mute, unable to walk. In Fig. 15 there are no purposeful conditioned reflexes (lower line) but some primitive conditioned reflexes of a non-purposeful character and marked unconditioned reflexes—these oc-

curred only to strong unconditioned stimuli (70 volts faradic current). These changes limited scope of this paper it is not possible to give a more detailed discussion of the

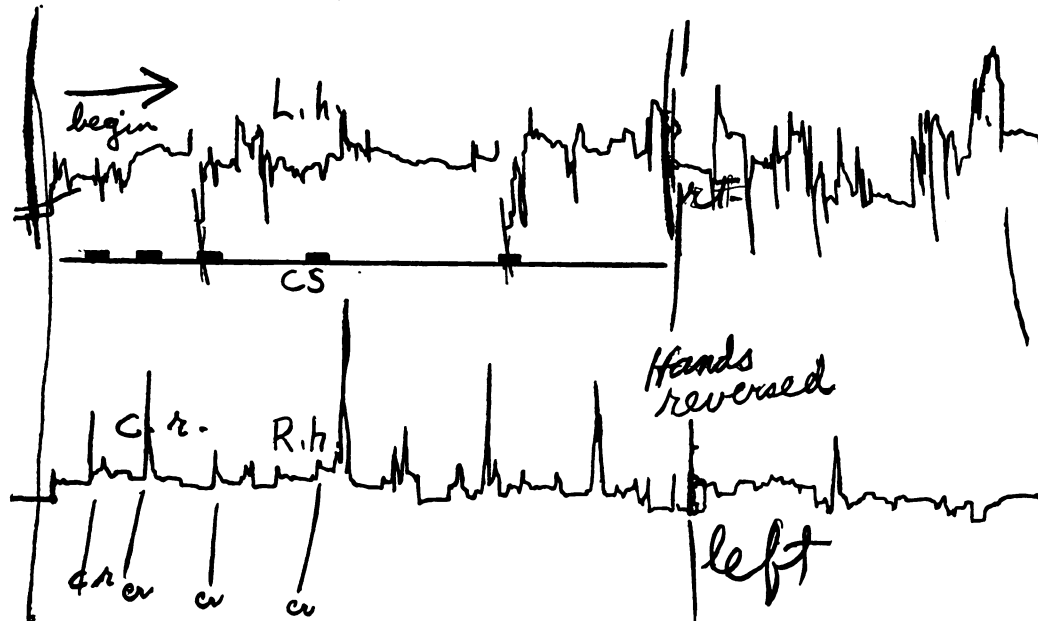


FIG. 13.—Pt. S.R. 31 October 1938. Increased intensity but ineffectual crs.

are seen in the middle line of Fig. 15. The respiration is suppressed and distorted, chiefly abdominal (upper line Fig. 15).

(In the figures the upper line represents the respiration, the middle line both the crs and the URs in the hand receiving the US, and the lower line the purposeful, integrated cr movements).

The records for the three above mentioned patients are sufficient to demonstrate the fact that the changes in the character of the crs bear a close relationship to the clinical condition as well as to the individual patient. First, in the schizophrenic the respiration was less disturbed as he was able to make the differentiation and give the appropriate reactions to the conditional stimuli. Second, it is observable that the cr record is parallel in the catatonic to his clinical condition—when he was able to converse and showed rapport the cr record was nearer normal. Third, the patterns of the three subjects are characteristic. Owing to the

anomalies in the various psychiatric and neurological diseases (*v. Gantt and Gantt and Muncie, supra*).

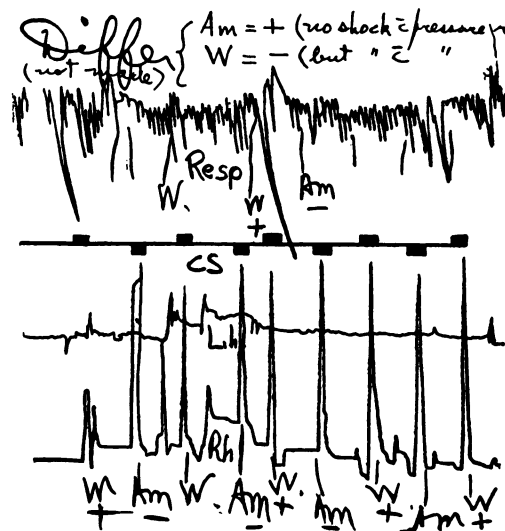


FIG. 14.—Pt. S.R. 30 January 1939. Adequate cr formation in patient during improvement, but no differentiation.

III

The above observations reveal a marked difference in many types of measures between stable dogs and humans and certain proven susceptible (labile) dogs and humans.

The significance of this type of data—the examination of function—is an argument for the direct measurement of function rather than prediction of function from structure, for it is function that we are ultimately

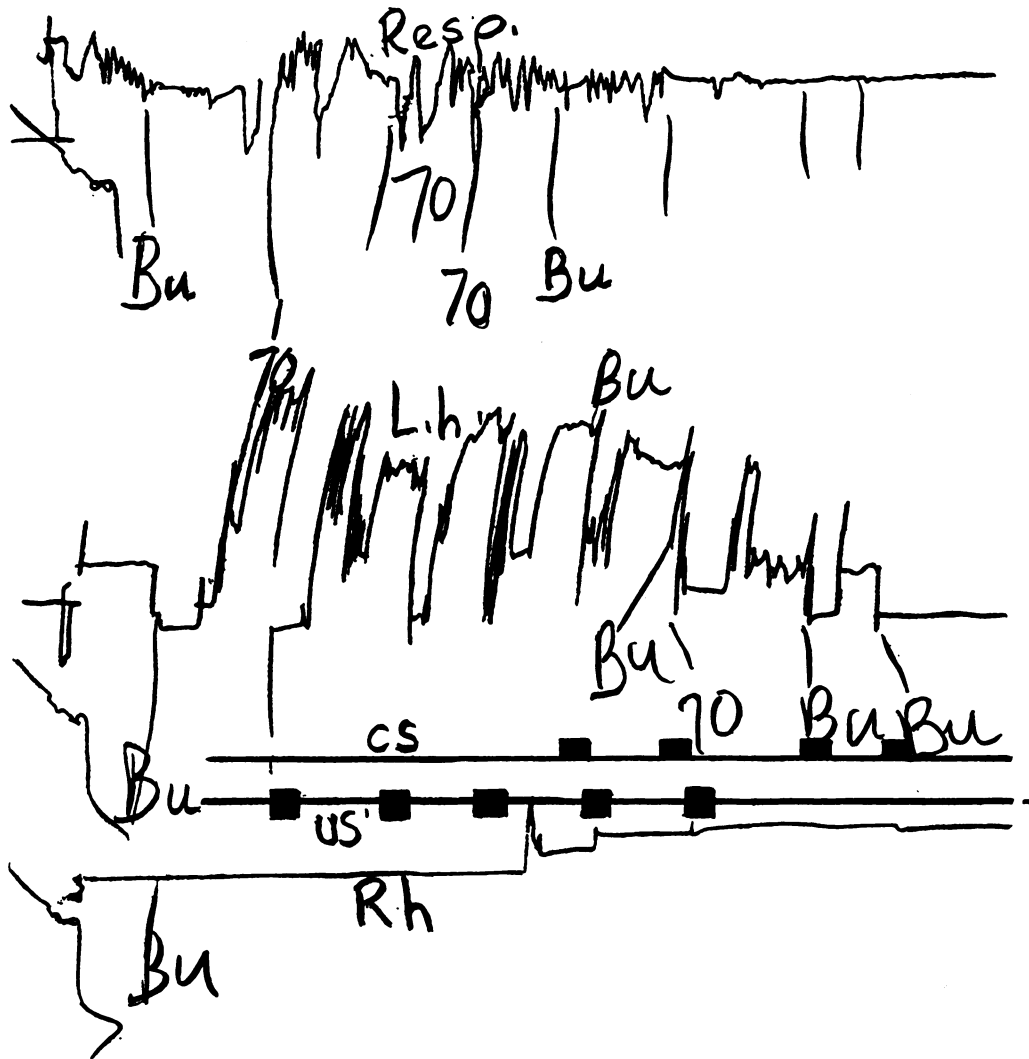


FIG. 15.—Pt. S.R. 6 March 1939. Patient in cataleptic state. Note absence of all cr formation (bottom line), marked tension and irregular movements in hand receiving shock (middle line) (L.h.) and marked irregularity and suppression of respiration (top line).

The method is a functional test that can be readily applied without the aid of language and in the face of only a fair degree of cooperativeness, *e.g.*, in catatonics. A measured strain can be introduced so that the degree of susceptibility may be registered for each individual.

mately concerned with and structure only as it determines or modifies function.

First, are we recording chiefly individual patterns of reactivity or actual susceptibility to the imposed strain? Second, are we measuring only susceptibility of certain physiological systems in the given individuals or

of the whole personality? For example it is known that one person will break down with a gastric ulcer, another with arteriosclerosis, another with hysterical paralysis under stress and conflict. Third, is the conflict (situation of stress) that we introduce concerned with items that are significant for the human subject or too trivial to be related with the important life experiences?

A satisfactory answer cannot be given to all these objections until further work has been completed. It is undoubtedly true that our tests do concern susceptibility of certain systems dependent upon the type of individual, giving us evidence not only of the susceptibility to breakdown but of the functional type of the individual and the relative susceptibility of the various systems. The question of system susceptibility *vs.* susceptibility of the whole personality requires careful analysis; it should be met by taking several measures that show a high

correlation with the personality rather than by using a single measure.

The question of the significance of the test for the dog can be answered by the fact that many animals show a permanent disturbance lasting for years as a result of the stress of the laboratory procedure and that the symptoms are definitely related to the artificial conflict. Though the test is incomparably less significant for the human subject than his painful life experiences, it nevertheless gives us important information concerning the pattern of reactivity and the susceptibility to an acute temporary disturbance even though the stress is an artificial one. The fact that it is a slight rather than a severe conflict warrants its use in the human being as a direct test of *function* related to the stability of the nervous system, *i. e.*, bearing a direct and close relation to the things about the individual with which we as psychiatrists are most concerned.